AN EVALUATION OF PRESCRIPTIVE TEACHING
OF SEVENTH-GRADE ARITHMETIC

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AN EVALUATION OF PRESCRIPTIVE TEACHING
OF SEVENTH-GRADE ARITHMETIC

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CHAPTER I

AN EVALUATION OF PRESCRIPTIVE TEACHING OF REMEDIAL SEVENTH-GRADE ARITHMETIC

Introduction

The need for mathematics in contemporary American society scarcely needs documentation. The great importance of teaching mathematics effectively to all students was pointed out by Welmer (23, p. 6). He mentioned the need in modern science, business, finance and industry. "It is not realistic to attempt to educate children properly without paying attention to these dominating forces in our environment."

Unfortunately, not all pupils are achieving at an acceptable rate in mathematics. Stenzel (17, p. 30) pointed this out graphically when she described the ordinary junior high school grade level. She indicated that about 10 per cent are excellent math pupils, 10 per cent are above average, 40 per cent "mediocre" and "then there are (10%) or more in the low-average, below average, and--alas,--remedial classes."

A reasonable explanation for this situation was pointed out by Newman (13, p. 753). "Teacher preparation, textbooks, and curriculum materials that are oriented to the 'average' pupil have little specific provision for the mathematically disadvantaged pupil." He further pointed out that if those
students are to successfully learn mathematics, provision must be made for them.

Recent curriculum reform movements in mathematics retain one of the basic weaknesses of the older programs, according to Travers (22, p. 591). They are directed toward the average and above average pupil.

Perhaps the greatest need of pupils who are consistently achieving below grade level in mathematics is for computational skills. When the potential employment prospects of pupils not attending college are considered, the need to compute with accuracy and speed is evident.

This study examined a possible solution to the problem of adequately meeting one of the needs of a large sector of our school population—the underachievers.

Statement of Problem

The problem of this study was to evaluate the effectiveness of prescriptive teaching of arithmetic to seventh grade pupils who were achieving at least one year below grade level in mathematics.

Purpose of Study

The purpose of the study was to determine the effect of prescriptive teaching of arithmetic to seventh grade pupils who are achieving at least one year below grade level in computation, concepts, and application skills in arithmetic. More specifically, the study was designed to determine the
effect of highly individualized prescriptive teaching of computation skills on the three areas of weakness—computation, concepts, and application skills.

Another purpose of the study was to compare the effectiveness of prescriptive teaching of arithmetic computation with ordinary classroom instruction on the three variables—computation, concepts, and applications.

Hypotheses

The following hypotheses were investigated by statistical analysis of data:

1. Mean gain in arithmetic computation of subjects in the experimental program will exceed that of the control subjects.

2. No significant difference will be found between the mean gain of the subjects in the experimental program and that of the control subjects in arithmetic concepts.

3. No significant difference will be found between the mean gain of the subjects in the experimental program and that of the control subjects in arithmetic applications.

4. The scores of the posttest for the subjects in the experimental program will be significantly higher than the pretest scores on arithmetic computation.

5. No significant difference will be found between pretest and posttest scores of the control subjects on arithmetic computation.
6. No significant difference will be found between the pretest and posttest scores of the subjects in the experimental program on arithmetic concepts.

7. No significant difference will be found between the pretests and posttest scores of the control subjects on arithmetic concepts.

8. No significant difference will be found between the pretest and the posttest scores of the subjects of the experimental program on arithmetic application.

9. No significant difference will be found between the pretest and the posttest scores of the control subjects on arithmetic application.

Theoretical Background

Educators have long decried the need for individualizing instruction. Newman (13, p. 753) pointed out that the ideal situation for individualizing instruction would be a student-tutor relationship. He realized, however, that this would be impractical because of the large number of qualified personnel required. He believed that the next best thing would be limited tutorial instruction for those who seem to need it most. In this study effort was made to individualize instruction for the experimental group.

Ferguson (4, p. 63) further emphasized the need for individualization when he said, "We must have opportunities for individualized instruction and provide the opportunity for
pupils to proceed at more nearly the speeds that are best suited for them. Different media must be explored.

Pouty (15, p. 10) gave a prerequisite necessary for adequately providing for individual differences:

The need for meaningful diagnosis leading to specific educational remediation of learning and behavior problems continues. Clearly, a necessity exists for an educational diagnosis based on the child's school behavior and abilities.

The concepts of programmed instruction were embodied in a design for individualized instruction by Lindvall (10, pp. 217-253).

1. The objectives to be achieved must be spelled out in terms of desired pupil behaviors.
2. To the extent possible, instruction objectives should be ordered in a sequence which makes for effective pupil progression with a minimum number of gaps or difficult steps and with little overlap or unnecessary repetition.
3. If pupils are to work through a curriculum on an individual basis, it is essential that instructional materials be such that pupils can learn from them without constant help from a teacher and can make steady progress in the mastery of the defined objectives.
4. In individualized instruction, care must be taken to find out what skills and knowledge each pupil possesses and to see that each one starts in the learning sequence at the point which is most appropriate for him.
5. For individualized instruction, conditions must be provided which permit each pupil to progress through a learning sequence at a pace determined by his own work habits and by his ability to master the designed instructional objectives.
6. If instruction is to be effective, it must make provisions for having the student actually carry out and practice the behavior which he is to learn.
7. Learning is enhanced if students receive rather immediate feedback concerning the correctness of their efforts in attempting to approximate a desired behavior.
8. The final criterion for judging any instructional sequence must be its effectiveness in producing changes in pupils.
These requirements were met by the program of instruction in this study.

Madden (12, p. 379) contends that "the current status of the measurement of computation and the diagnosis of deficiencies seems to be very good."

Goodlad (6, p. 8) contends that

Human variability demands alternatives.
The sound selection of alternatives demands diagnosis of the individual and the availability of viable alternatives from which to prescribe. Diagnosis and prescription are teaching functions.

Creative diagnosis and prescription by teachers must be facilitated—if we are ever to talk less and act more with respect to meeting the needs of individual learners.

Of the various techniques available as alternatives for individualizing instruction, self-instructional material is among the best. Much resistance to the use of programmed material has been aroused. Lackner (9, p. 181) attempts to alleviate some of the misgiving.

Perhaps current hostility in educational circles toward programmed learning is due to a misconception of its purpose...Programmed learning is not intended to replace the classroom teacher but rather to supplement, complement, and augment the teacher's efforts. As the writer views it, anticipated purposes of teaching, such as providing remedial work, supplementing a topic, or enlarging existing teaching techniques, are the objective of any programmed text or self-instructional learning.

If programmed learning was originally intended to replace the classroom teacher, it has fallen short of its goal. Yet, programmed learning has been found generally to be as effective as classroom teaching...The reader should be particularly aware of the cited purpose of the programmed materials.
Suppes (21, p. 304) described the results of most reported studies on programmed instruction by saying that pupils using well-written programmed material "will be able to master some material as well as students in a regular class in somewhat less time."

Definition of Terms

Terms which have special meaning in this study are listed below:

Prescriptive teaching.—The term "prescriptive teaching" is used to describe a technique in which individual differences on a number of variables including I.Q. scores, achievement in arithmetic areas and achievement in reading are determinants in the selection of learning experiences for the individual pupil.

Experimental program.—The experimental program is the total program of each subject assigned to the experimental group. No effort will be made to isolate the effects of specific treatments used.

Auditory reading assistance.—"Auditory reading assistance" is the term used to describe the use of an audio-tape recording to assist students in reading the written instructions, directions, and answer explanations of a linear program.
Tests and Materials

Below is a list of all instructional materials and testing instruments employed in this study:

1. **Lessons for Self-Instruction in Basic Skills: Arithmetic Fundamentals.**— These twenty programmed booklets on arithmetic computation are sub-divided into specific skill areas described below and range in difficulty from grade three through nine or higher. Leo J. Bruckner (1) is the author. Set G for grades nine and above was not used in the study.

2. **Audio-Graphic Programmed Instruction: Reducing Fractions.**— This is a program developed by James H. Peck (14) and Allan G. Calkin of the Gary Job Corps Training Center. This is a programmed lesson in which audio-taped explanations, discussions of answers, directions, responses, encouragement, and verbal emphasis are presented with graphic (printed) diagrams, illustrations, numerals, short phrases, and responses.

3. **Decimals and Per Cents.**— M. Daniel Smith (16) wrote this linear programmed text which contains eleven sections. Sections one through three are designed to teach place values and decimal numbers; sections four through six introduce per cents, using fractions to develop understanding of the relationships between decimals and per cents; sections seven and eight teach the symmetric property of equations; section eight teaches multiplication and division with decimal numbers; sections nine, ten, and eleven develop techniques
for solving simple word problems involving decimals and per cents. Sections of this program were used with and without auditory reading assistance.

4. A S M D Addition, A S M D Subtraction, A S M D Multiplication, and A S M D Division. These four programmed texts cover the four operations with whole numbers. They were written by John D. Hancock (7) and others. The format of this material makes it easy to assign those sections needed by the students without assigning the whole book. Due to the linear nature of this book, they were used both with and without auditory reading assistance.

5. Programmed Math: Fractions. This book is a programmed text covering the basic concept of fractions, additions, subtraction, multiplication and division of common fractions, multiplication and division of fractions by whole numbers, reducing fractions, addition and subtraction of mixed numbers, converting improper fractions to whole or mixed numbers, borrowing in subtraction of fractions, multiplication of mixed numbers, and addition and subtraction of unlike fractions and mixed numbers. This book was written by Marjorie Sullivan (20) and associates. The linear format made this book amenable to auditory reading assistance.

6. Decimals and Percentage I, Decimals. William Hauck (8) and others wrote this programmed text. The book is divided into seven parts: the first part is on the theory of decimal fractions; the second part is on addition and subtraction of decimals; the third part is on rounding decimals; the fourth
part deals with multiplying decimals; the fifth part covers division of decimals; the sixth part deals with decimal and common fraction equivalents; the last part is a review of the first six parts. Although this program had a linear format, the opportunity never arose to use auditory reading assistance with this program.

7. Decimals and Percentage II, Percentage.--This programmed text was a continuation of Decimals and Percentage I. It, too, was written by Hauck (8) and others. This book was divided into four parts: The first, an introduction to per cent; the second, on equations and per cent; the third, on discount and interest; and the last, a review of the previous three. Auditory reading assistance was not used with this material because no student working with this program needed it.

9. Honor Learning System: Fractions I and Fractions II.--These two programs were developed by Honor Products Company (5). The programs were presented by the Honor Teaching Machine. The program stresses understanding fractions, addition and subtraction of increasingly difficult fractions and mixed numbers, as well as terminology, reducing fractions and mixed number operations. Assignment of small sections of the program was not recommended.

9. L.S.I Locators in Arithmetic Fundamentals.--This is a set of four diagnostic tests published by the California Test Bureau (11). Although they were designed to be used with
Lessons for Self Instruction, the items are such that the individual needs of each subject can be identified sufficiently to provide remedial experiences by other means as well.

10. Comprehensive Test of Basic Skills, level 2, form Q, Arithmetic Skills Area (2).—This is a test recently developed by California Test Bureau. It was designed to measure computation, concepts, and application skills. Level 2, the level selected for this study, was designed for use with fourth, fifth, and sixth grade pupils, but since the achievement level of the subjects in this study fell generally within this range, it was selected instead of a higher level. This test was selected as a pretest.

11. Comprehensive Test of Basic Skills, level 2, form R, Arithmetic Skills Area (3).—This is a comparable form of the above test. It was selected as a posttest.

12. Science Research Associates (SRA) Achievement Tests Arithmetic Scales (18).—These three tests were employed, not only as criteria for selection of population, but also as covariates.

13. Science Research Associates (SRA) Primary Mental Abilities Test (19).—Two scales of this test—number facilities and composite score—were used as covariates.

Basic Assumptions

It was assumed that the twenty-five best matched pairs, matched on arithmetic computation, concept, and application skills, represent a random sample of the total population of under-achieving pupils from which they were drawn.
Limitations of the Study

1. The study included pupils from only one North-central-Texas school.
2. This study was concerned only with achievement in arithmetic.
3. This study included only seven weeks of concentrated instruction.

A study involving a different period of time or a less concentrated approach would conceivably produce different results.

Procedure

One hundred twenty-three pupils who scored at or below the fifth year, eighth month on all three arithmetic scales of the SRA Achievement Test in the fall of 1968 were given Form Q, Level 2 of the Arithmetic section of the Comprehensive Test of Basic Skills (2), a test developed by the staff of California Test Bureau, as a pretest. All subjects scoring above a specified score (40) on the computation scale were eliminated from the study.

The remaining pupils were matched on the three scales of the pretest—computation, concepts, and applications. The twenty-five best matched pairs of pupils were used in the study. By the toss of a coin one subject from each pair was placed in the experimental program and the other served as the control. The control subjects returned to their usual classes with no further special attention until the posttest.

The subjects in the experimental program met daily with a certified mathematics teacher at the time they regularly
would meet their mathematics classes. These pupils were given
LSI Locators in Arithmetic Fundamentals (11). Frequent
diagnostic examinations of the subjects progress were made
during the course of the study on an individual basis. Since
small groups of pupils were taught--a total of twenty-five
during five periods--much individual attention could be given
to each pupil.

Self-instructional material was issued to each subject
on the basis of his needs as diagnosed by LSI Locators.
All subjects with a reading level below the sixth grade in the
fall were given linear programs with auditory reading assis-
tance or Audio-Graphic Programs, depending on their individual
needs. The instructor had frequent individual conferences
with each subject to encourage and reinforce him.

All materials used were designed for the improvement of
computational skills since these were considered of greatest
importance to the pupils involved. The instructor did con-
stantly strive to maintain a positive attitude on the part of
subjects by emphasizing their successes and minimizing their
failures. Individual tutoring by the instructor was used
when it was deemed necessary or appropriate.

At the conclusion of the seven week experimental pro-
gram, Form R, Level 2 of the Arithmetic section of the Com-
prehensive Test of Basic Skills (3) was administered to both
the experimental and control subjects as a posttest.
Treatment of Data

Two separate approaches were used in analyzing the results of pretest and posttest: the first for testing hypotheses one, two, and three and the second for testing hypotheses four through nine.

The linear effect of age, sex, performance on SRA Achievement Tests in all three arithmetic areas—computation, concepts, and reasoning—and I.Q. as measured by SRA Primary Mental Ability Test were removed by a covariate technique from gain scores for both the experimental and control groups.

In testing hypotheses one, two, and three, the pretest scores were also equated by residualized gain for all subject gains. The difference between the gain scores on computation, concepts and application of the subjects in the experimental program and the control subjects were simultaneously tested by use of Hotellings T-square. The .05 level of significance was required for rejecting the null hypothesis.

If the null hypothesis was rejected, the groups would be compared on each variable by simultaneous confidence intervals. Again the .05 level of significance would be required for rejecting the null hypotheses.

For the second approach Fisher’s t tests with repeated measures was run comparing the pretest scores with the posttest scores on each of the three variables for the control subjects.
and the subjects in the experimental program. To reduce the possibility of chance occurrence of a significance due to repeated use of \( t \), the .01 level of significance was required to reject the null hypotheses.
CHAPTER BIBLIOGRAPHY


2. Comprehensive Test of Basic Skills, Level 2, Form Q, Monterey, California, California Test Bureau, 1968.

3. Comprehensive Test of Basic Skills, Level 2, Form R, Monterey, California, California Test Bureau, 1969.


CHAPTER II

REVIEW OF RELATED RESEARCH

This chapter is divided into three parts, each of which concerns an integral aspect of this study. The first section is on individualization of instruction, which is at the heart of prescriptive teaching. The second section deals with programmed materials. The last section contains the available research on the materials utilized in this study.

Individualization of Instruction

Among the first approaches to providing for individual differences was ability grouping. The general result of most studies in which ability grouping was compared with heterogeneous grouping was "no significant difference" (4, 8, 6, 11, 12, 20, 26). There were a number of reasons for this result. Two reasons were that, even with ability grouping, a wide range of abilities was still found in nearly all classes (6, 16, 26), and the learning activities and even the materials to be learned were usually the same for all groups regardless of the abilities of the pupils in the class (6, 20, 26).

A logical extension of the concept of ability grouping was intraclass grouping. In an experiment conducted by John A. Dewar (10), intraclass grouping for arithmetic instruction in the sixth-grade produced promising results.
He used eight upper middle class schools in one Kansas county—four as experimental and four as control schools. It was found that the two groups did not differ significantly at the beginning of the study. The control classes received the usual whole group instruction and used the usual sixth-grade text. The experimental classes were divided into three groups—high, average, and low. Textbook material of varied form and a curriculum outline for each of the groups was provided by the investigator for the experimental classes. The two groups of classes were compared on the Stanford Achievement Arithmetic Test at the conclusion of the study. A comparison of means showed superiority for the experimental classes beyond the .05 level of significance. When the subgroups in the experimental classes were compared with comparable subgroups from the control classes, a significant difference was found between the respective low subgroups and high subgroups. No significant difference was found between the average subgroups. All significant differences favored the experimental classes.

Several articles were found that had been written by people who had tried varying degrees of individualization in the teaching of arithmetic and other subjects. Helen Redbird (27) described a program in which allowance was made for individual differences in speed of learning. She used basically a textbook approach with some programmed enrichment. She reported that the program was very satisfactory as far as pupil learning was concerned, but it took a great deal of time.
Franklyn Searight (28) described an individualized program similar to that described by Redbird. In his program, as in Redbird's, all pupils did about the same work, but they did it at their own pace. Searight avoided the paper-grading problems described by Redbird by allowing his fifth-grade pupils to correct their own work. Pupils were ready to progress from one topic to another. He would instruct them individually or in small groups as the situation required. He would then give each pupil an assignment list which would lead through problems of varying degrees of difficulty on that topic. As each pupil completed an assignment on his list he would check his own work. Although Searight found this technique very effective, he pointed out that it would not be appropriate for all teachers.

In a study to determine the feasibility of building an intermediate mathematic curriculum including both the "new math" and individualized instruction, Elaine Bartel (3) concluded that such a program was feasible. The feasibility was determined by the answers to the following four questions.

1. Are adequate materials currently available for the establishment of a library of textbooks and materials which pupils can use in a logical and meaningful way, and from which pupils can make selections without undue confusion or feelings of frustration?
2. Do the teachers generally find the program teachable, and do they like it?
3. Do children like this method of studying arithmetic?
4. Are pupils able to make reasonable progress while participating in such a program? (3, p. 114)

Two fourth-grade classes were selected for the experimental study, while one class was used as a control. The control and experimental classes were compared by analysis.
of covariance to adjust for initial differences in ability and achievement. It was found that adequate material was available and that children could adequately select from this material. Moreover, both teachers and pupils participating in this program found it quite desirable. Only one significant difference was found between the experimental and control subjects. The experimental subjects did significantly better ($P < .01$) than the control subjects in arithmetic concepts.

Victor L. Fisher (15) conducted an experimental study to determine the effect of independent progress in elementary arithmetic and immediate reinforcement. Sixth grade subjects were randomly assigned to two experimental and one control class. The first experimental class was given assignments and each pupil was allowed to progress at his own rate. The students in this class were also allowed to check each assignment as they completed it. The second experimental group progressed as a group, but again the pupils were allowed to check their own work. The control group progressed as a group, but the teachers checked the assignments daily. All three groups progressed through ninety-two predetermined assignments. All groups used the same basic test, the same room, and the same teacher taught them all. The same evaluative process was used for all groups. No significant differences in achievement as measured by the California Achievement Test, Arithmetic Section was found. It was noted, however, the first experimental group progressed more rapidly and their achievement was as
high or higher than the other two groups. It was concluded that, on the basis of this investigation, allowing students to progress at their own rate and checking their own work was an efficient and effective technique.

Jettye F. Grant (17) conducted an experiment to compare the effectiveness of a longitudinal program of individualized instruction with another experimental program and with a control group, on achievement in language arts, arithmetic, science, and social studies as measured by standardized test. A further comparison was made with the norms for the criteria test.

The instructional program provided for children in Experimental Group A had the following important characteristics: (1) Pupils managed themselves through a system of self-government; (2) they helped to set their own goals through the development of individual study contracts; (3) they learned how to learn by themselves; to identify instructional needs, to work out a study plan, to follow through on the study plan, and to check results; (4) each child operated on a flexible daily schedule enabling him to take up the day's learning tasks in order of their importance to him, and to complete each one before moving to the next; (5) pupils progressed individually, without being pushed or held back to keep pace with other pupils; (6) involvement of parents and guardians in development of the instructional program insured their cooperation and assistance in class projects; (7) planned sequences of instruction were used as check lists of skills and abilities to be developed by each child (17, p. 23).

Experimental group B shared some of the materials used by group A, while the third group, which served as the control, was taught by conventional textbook lecture technique as a group. Random stratified sampling was the basis for the selection of subjects for all three groups. Although a
trend toward greater gains for experimental group A was found, there was not significant evidence to reject the null hypothesis that the subjects in the individualized program would not differ significantly from the other two groups in achievement.

The above studies lacked one of the critical aspects of this study. All subjects were taught the same material regardless of their previous level of achievement and ability. One other weakness which tended to lead to acceptance of the null hypothesis in these studies was the lack of a criterion measure designed to measure the specific objectives of the course of study.

It was concluded by Donald Deep (9) after a study to determine the relative effect of an individually prescribed arithmetic program on the achievement of high, average and low ability children in the intermediate grades of elementary school that standard tests designed to measure skills appropriate for grade level were not appropriate for measuring the effect of individualized instruction since, if the program is prescriptive, subjects will be working at above-normal and below-normal grade level. In his experiment he used one experimental and two control schools. In order to find out if individually prescribed instruction differentially affected students of varying ability levels, the subjects in the experimental classes were taught arithmetic by individual prescription. Classes in the control schools were taught by
conventional textbook methods. When gain scores were adjusted for pretest differences by analysis of covariance, no significant differences were found among the different ability groups in the experimental school. Significant differences were found among subjects in the control schools. It was concluded that a program of individually prescribed instruction was less discriminatory against slower students than was the conventional teaching method.

In a study similar to the one presently being conducted, J. W. Tilton (30) was interested in discovering whether or not a small amount of individualization would produce measurable gains. In Tilton's study a pretest was administered to one-hundred, thirty-eight fourth grade pupils. Nineteen matched pairs of pupils with low scores were selected for the study.

For four weeks the subjects in the experimental group received twenty minutes of individualized remedial help weekly. Remedial effort was based upon a standardized diagnostic test. Three weeks elapsed between the last twenty minutes of individualized instruction and the posttest. The findings indicated that the experimental subjects who were about one year behind grade expectancy in addition, subtraction, division, and multiplication made five months more progress than would have been the case without individualized instruction. This difference was significant at the .01 level. It was concluded, therefore, that even as small an amount of individualized instruction as eighty minutes can be very worthwhile.
Programmed Materials

There is no shortage in research on programmed or self-instructional material. Below are but a few of the two-thousand-plus studies in this area. The studies cited have a specific relationship to the study being conducted for various reasons. These reasons are discussed below.

Programmed or self-instructional material is frequently presented as a text. James Wesson (31) attempted to determine the relative effectiveness of utilizing programmed text. He also compared the programmed material utilized in three ways with a control group taught with a conventional text. The first experimental group was taught by the conventional method but a programmed text was used as the text for the course. In the second experimental group, all pupils begin at the beginning of the programmed text and each worked at his own rate. The third experimental treatment was very much like the second. The only difference between the two was that pupils were allowed to receive advance placement based on a pretest. A fourth group was taught with a conventional textbook. There were three classes in each group for total sample of two hundred eighty-eight pupils. A posttest indicated that there was no significant difference in achievement gains among the four groups. Both teachers and pupils liked the second and third programs. The first program found the least favor among the four. Due to the great individualized gains of some of the pupils in the third experimental group, it was preferred.
Wesson's study and the conclusion he reached tended to support not only programmed instruction, but also individualization of instruction.

John F. Feldhusen (13) reported on a study that compared the effectiveness of programmed learning and carefully planned regimen of teacher taught activities. Thirteen seventh grade subjects were in the control and experimental groups. Both teachers and pupils were reversed to control for systematic differences in the absence of randomization. Subjects in the control group were taught a carefully planned program which corresponded in content with the self-instructional material. After seven weeks of instruction, the Arithmetic Subtest of the Iowa Every Pupil Test of Basic Skills was administered. No significant differences were found in the two groups at any time. It was concluded that the live teachers and the programmed material were equally effective in teaching basic skills and concepts. It was also found that under the carefully planned regimen provided by a live teacher as well as under programmed instruction each group gained approximately one full year in arithmetic skills during fourteen weeks of instruction. This study would indicate that unusually large gains may be obtained when instruction is directed toward specific goals.

Frank W. Banghart (2) reported on a study designed to compare programmed with non-programmed material on fourth grade arithmetic problem solving, comprehension, and total score. The programmed text utilized was one designed for
fourth-graders. It covered all concepts and skills taught at this level. The control subjects used a non-programmed text and the supplementary material generally used. The sample included one hundred ninety-five fourth graders. These subjects represented a cross section of fourth grade children in the school district in terms of intelligence, achievement, and socio-economic status. The experimental group showed significantly greater gain in total score (P<.05) and comprehension (P,.01). No significant difference was found in problem solving due apparently to the large variability encountered. It was concluded that the programmed instruction was superior to classroom instruction for comprehension and total score and it was at least as good on problem solving.

Glen E. Fincher (14) conducted a study comparing programmed and conventional methods of teaching addition and subtraction of fractions to fifth grade pupils. Ten classes were randomly assigned to experimental and control groups. A total of three hundred and nine subjects were included. A pretest indicated that the three groups were not different initially in mental ability or computational skills. Both the control and experimental subjects studied the addition and subtraction of fractions for four weeks. The control subjects were taught with the adopted text and conventional instruction with homework. The experimental subjects used only the programmed material with no homework. It was found that the gains of the experimental group were significantly higher
(P .05) than the gains of the control group. After four weeks a test was administered to determine retention. The retention was determined by subtracting the posttest from the delayed test. No significant difference was found.

Jack Miller (24) conducted a study to compare the effectiveness of two approaches of the teaching of multiplication of fractions. Subjects in the experimental program used only programmed material for drill. Control subjects received conventional instruction with the adopted text. After nine days of instruction, gain scores were compared for the two groups. It was found that the experimental subjects did significantly better than the control subjects regardless of ability.

In a study to compare the effectiveness and efficiency of a self-instruction program on multiplication of fractions with conventional instruction on this topic, Charles Arvin (1) randomly assigned six sixth grade classes to an experimental and six to a control group. At the completion of instruction, a thirty-four item posttest was administered by the teachers involved. With I.Q. scores as a covariate, analysis of covariance was used for comparison. No significant difference was found; however, the experimental group completed the unit in about one-half the time taken by the control subjects.

In a similar study Calvin Greatsinger (13) compared programmed and conventional text methods for teaching division of fractions. He randomly assigned one sixth grade class in each of six schools to the experimental group and one to the
control group. The subjects in the experimental group received instruction only from programmed material. A forty-item criterion test was administered by the teacher when the pupils completed the unit. Analysis of covariance showed no significant difference on the criterion measures; however, again the experimental subjects completed the problems in less than one-half the time taken by the control subjects.

A study was conducted by Bruce Meadowcroft (22) to determine if there was a difference between the achievement and attitude of pupils taught by textbook-lecture methods and those taught by a combination of programmed learning and supplementary teaching.

For Meadowcroft's study two-hundred ninety-four seventh grade subjects were randomly assigned to two groups. Ten classes were formed in each group which included two accelerated, two above average, four average, and two below average. The experimental subjects received approximately seventy per cent of their instruction by programmed material and thirty per cent of the time was spent in supplementary teaching. The control classes were taught by the conventional textbook lecture method. The results indicated that neither group proved superior in arithmetic computation, reasoning, and total scores. Significance was discovered, however, among the small subgroups. The control method proved superior to the experimental method for the accelerated classes. There was no significant difference with the above average
and slow students, and the average realized greater gain with the experimental method. Neither method resulted in a superior attitude on the part of the pupils toward mathematics regardless of involvement with major groups or subgroups. The experimental groups did experience significant changes in attitude toward both mathematics and programmed material.

Programmed material covering the same topics included in this study were utilized in the studies mentioned above. At no time did pupils in the control group receiving conventional instruction show marked superiority over pupils utilizing programmed instruction. This was especially true of slow students even though the programmed materials were not necessarily appropriate for their level of achievement and ability.

In a study conducted by Glenda Tanner (29) it was observed that the usual junior high school test battery was inappropriate for measuring the effectiveness of remedial programmed instruction. Tanner's study was designed to investigate the effectiveness of programmed instruction with seventh grade low achievers in arithmetic when compared with a remedial class taught by the conventional lecture textbook method. The subjects were one hundred seventy-nine pupils from Georgia schools that had been classified by their respective school systems as belonging to the lowest of three achievement groups on the basis of standardized test. No significant difference as measured by achievement test
designed for junior high pupils was found when initial differences in achievement, intelligence, social position, and sex was controlled. Significant differences were, however, found in two of the schools in arithmetic reasoning. The differences favored the control group. It was noted that instruction in the experimental groups was centered at the fifth grade level and that the textbooks used in the control classes were for sixth and seventh grade level. Tanner concluded that a test for a lower grade level would have more accurately measured the ability of both the control and experimental subjects.

Tanner's study pointed out the extreme importance of selecting a criterion measure that accurately evaluates the specific objectives of teaching whether it be by programmed instruction or any other teaching technique.

In a follow-up study of the previously cited experiment Bruce Meadowcroft (23) tried to determine the effect of programmed instruction in seventh grade arithmetic on conventionally taught eighth grade arithmetic the following year. Of the two hundred ninety-four subjects in the seventh grade study, one hundred twenty-seven experimental and one hundred twenty-two control subjects remained in the school system the following year. In the previous study the experimental subjects had received seventy per cent of their arithmetic instruction by way of programmed material and thirty per cent by teacher instruction. The control group had received
conventional classroom instruction. No significant overall difference had been observed at the end of the seventh grade study. Meadowcroft compared the arithmetic achievement scores of the two groups at the end of the seventh grade study. No significant differences were found between the two groups.

The scores of the subgroups of the experimental and control groups—high, average, low—showed a tendency toward convergence. Those groups which had made greatest gains in the seventh grade tended to make less gain in the eighth grade and conversely, those groups which had made somewhat less gain in the seventh grade tended to make greater gains in the eighth grade. Meadowcroft concluded that programmed instruction in the seventh grade had no adverse effect on achievement in the eighth grade. In fact, those subjects who received programmed instruction in the seventh grade fared quite well with the control group in the eighth grade.

Instructional Material Used In This Study

A variety of different materials and approaches were used in this study. Unfortunately, test data on all of these materials was not available. Below is a summary of the research data presently available on each of the instruments used.

It was pointed out by James M. Peck (25) of the Gary Job Corp Training Center, the author of the Audio-graphic Program, that using programmed instruction with poor readers had been somewhat less than tremendously successful. This lack of success is the result of a number of factors not the least of
which is difficulty in understanding the written instructions and explanations. In an effort to overcome this problem, he developed the Audio-graphic Programmed Material. In a letter describing these materials, Peck said,

These materials consist of an audio portion—a voice on tape, and a graphic portion—a printed booklet as the name implies. We find the audio portion, through verbal inflection and tone of voice can: provide explanations that are often misread; offer encouragement; give directions; allow alternative responses; discuss answers; make points clear that, when read, might leave doubt; and relax the student. This last point may at first seem trivial, but it is not. The printed word can seem very cold, austere, and threatening to a student who lacks confidence due to his difficulty in reading and understanding arithmetic. In the graphic portion we use diagrams, illustrations, arrows, numerals, short phrases, and alternative responses (25, p. 1).

The data available on the program used, Reducing Fractions, indicated that the average time to complete the program was ninety minutes. The average pretest scores for the subjects at the Job Corp Center was twenty-four per cent. After completing the program the average posttest score on the same instrument was seventy-one per cent. In order to determine the retention of the subjects, a third testing was administered after sixty-four days. The average score on this retention test was seventy-five per cent. Unfortunately, no test of significance was used, however, it would appear based upon the large mean difference found between the pretest and posttest that this difference would be significant.

To test the effectiveness of the independent use of the set of programmed texts, Lesson for Self-Instruction, to overcome basic weaknesses in language and arithmetic,
Darold Bobier (5) conducted an experimental study. Students displaying weaknesses on a proficiency test used as a pretest were randomly assigned to control and experimental treatment. Four experimental conditions were designed with varying degrees of student responsibility for using the text. In addition, two control situations were set up—one with remedial classes in language and arithmetic skills and one with no special instructions. The program lasted nine weeks. A posttest administered at the completion of the program showed significant gains ($p < .01$) for all treatment conditions in both language and arithmetic. When the difference among all groups in arithmetic gain were tested, no significant difference was found. Based on observations made, Bobier reached four conclusions: (1) Low achieving pupils lack the necessary motivation for independent use of the programmed text. (2) Low achieving pupils need guidelines to pace them through the programmed materials. (3) Lessons for Self-Instruction hold promise for the remediation of pupils with experience of repeated failure. (4) Sex differences do not effect the successful use of Lessons for Self-Instruction.

In the Teacher’s Manual for Decimals and Percentage I and II, William Hauck (21) gave the following description of test results.

When tested on junior high school students of average ability, the final edition of the program consistently yielded mean error rates of less than 12 per cent and mean achievement scores between 75 and 84 per cent. In all cases, the program was
used without teacher participation; i.e., the subject was taught only by the program. Naturally, higher scores can be expected with teacher participation. Test on ten students under laboratory conditions yielded a mean score of 89 per cent (21, p. 1).

Again no test of significance was employed.

The test results of Honor Roll Programs prepared by Bolt, Beranek, and Newman Incorporated (7) contained the results of a study on programs #505 and 506--Fractions I and II. The subjects in this study were seventy-eight seventh graders from a middle- and lower-middle-class nonurban community who were homogeneously grouped in mathematics. Groups B, C and D were bright, and high achieving pupils. Group E was made up of low achieving pupils with reading difficulties. Group C and D, who had learned fractions previously to exposure to the program received both programmed rolls. Group E learned fractions with both programmed rolls, with no previous exposure. Group B received the second programmed roll only, plus regular classroom instruction in fractions. Before the instruction began, the entire group was pretested on a mathematics achievement test. At the completion of the study, all subjects were given a posttest. The results showed that the mean gain of all subjects was significant beyond the .01 level. It is more important to this study, however, that the mean gain achieved by group E--the low achievers--was significant beyond the .002 level. With regards to this group the following conclusion was reached.
Largest gains were made by Group E which was entirely machine-taught, retarded in reading, and of generally lower I.Q. than groups B, C and D. Since Group E had minimal previous exposure to formal instruction in fractions, this group gives us a good indication of the effect of programmed instruction with rolls #505 and #506 (Fractions I and Fractions II) (7, p. 10).

In the forward of the ASMD texts, John Hancock (19) explained that these programs were designed for upper grade pupils who still have not mastered the four fundamental arithmetic operations with whole numbers. Hancock made the following statement about tests of these texts:

(These programs have) been tested on such pupils who have encountered difficulty through the traditional teaching process, and the results of the testing indicates substantial improvement for many of these pupils; however, in no sense is the program a panacea. The terminal behavior of some pupils at the end of the program will indicate that additional assistance is still required.

The material presented here, particularly when used in conjunction with a teacher conscious of the problem of pupil motivation, will produce for many pupils the satisfactory performance in addition (subtraction, multiplication, and division) which has escaped them throughout their school careers (19, p. ii).

Unfortunately no tests of significance nor even statistical data about Hancock's text was available.

No test data or discussion of test results was found on Decimals and Per Cents or Programmed Math: Fractions. In a letter from the Webster Division of McGraw-Hill Incorporated, it was pointed out, however, that the Programmed Math series was being used by over 20,000 people in job corps training centers and other programs of this nature for the culturally deprived. At the time of writing no test results were available.
The selection of materials was based primarily on the objectives and the level of mathematics presented. The readability and simplicity of the materials were also primary factors in this selection.

From a review of related research the following general conclusions can be drawn: (1) Individualized instruction produces achievement gains at least as great as conventional classroom instruction. (2) Great care must be taken in the selection of a criterion instrument since the material covered is not necessarily within the range of a standardized achievement test designed for grade level. (3) To be individualized, instruction must take into consideration the initial level of achievement of each pupil.

Certain conclusions may be reached about self-instructional or programmed materials. (1) Pupils achieve as well with a well written program as with classroom instruction. (2) Pupils can cover the same material in somewhat less time with programmed material. (3) Pupil retention after using programmed material is as good as after conventional classroom instruction. (4) Programmed instruction has no adverse effect on the future performance of pupils.
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2. Banghart, Frank W. and others, "An Experimental Study of Programmed Versus Traditional Elementary School Mathematics," The Arithmetic Teacher, 10 (April, 1963), 199-204.


CHAPTER III

METHOD

Because of the unique instructional techniques employed in this experiment, a detailed description of the instructional progression is presented in this chapter as well as the experimental procedure. The last section will deal with the treatment of the data procured.

Procedure

The results of the arithmetic tests of the Science Research Associates (S R A) Achievement Battery (9) for all pupils in the Denton Junior High School seventh grade were examined. These tests had been administered in October, prior to the start of this experiment. Only those pupils scoring at least one full year below grade level on all three tests of the S R A Arithmetic Section—Reasoning, Concepts, and Computation—were involved in the study. These pupils will be referred to as 'underachievers'.

One hundred twenty-three of the one hundred twenty-five "underachievers" were administered the Arithmetic Skills Area of the Comprehensive Test of Basic Skills (2), level two, form Q. All pupils scoring above forty on the computation test were eliminated from the study to reduce the ceiling effect on the posttest since the highest possible score was forty-eight.
The twenty-five best matched pairs on the three Arithmetic Skills Area Tests—Computation, Concepts and Applications—were selected for the study. The greatest variation allowed for any pair was two points on any one area and three points on total score.

Two matched groups were formed by assigning one subject from each pair to each group by a coin toss. The experimental and control groups were then decided by a coin toss.

The control subjects returned to their usual classes until the posttest with no special attention from the experimenter. The experimental subjects reported to a room provided for the experiment instead of their usual arithmetic class five days a week for seven weeks where they received the experimental program described below.

At the end of the seven week period, the experimental subjects received, with their match, the Arithmetic Skills Area of the Comprehensive Test of Basic Skills (3), level two, form R, as a posttest.

Description of Experimental Program

The L S I Locators in Arithmetic Fundamentals (7) served as a continuing guide for selecting sequential activity areas for the subjects in the experimental program.

In the cases of fractions, decimals, and per cent, it was often necessary to familiarize the subjects with some of the fundamental concepts behind the kinds of numbers being
used. In order to perform operations with these numbers, some idea of theoretical construct of the numbers was necessary. This was deemed necessary if the subject displayed a marked weakness in manipulating these numbers in all operations.

The first approach used with all subjects classified as readers (reading on at least sixth grade level) was Lessons for Self-Instruction (1). For those subjects classified as non-readers (reading below sixth grade level), the materials listed after each level were utilized with auditory reading assistance. For readers who still displayed weakness after working with L S I material, the materials listed after each level were employed without reading assistance.

Below is a level-by-level, operation-by-operation description of problems attacked by this program. The order in which they are presented here is generally the order in which they are treated. Minor variations appeared with the various materials employed. The levels referred to are as they appeared on the L S I Locators. The levels are as follows.

Level AB includes the following:

1. Addition facts and addition of one and two digit numbers.
2. Subtraction of one and two digit numbers.
3. Multiplication facts and multiplication of a two digit number by a one digit number.
4. Addition of two and small three digit numbers.
(5) Subtraction of a two digit number from a small three digit number.

(6) Multiplication of a small two or three digit number by a two digit number.

(7) Division of a two or three digit number by a one digit number with no remainder.

(8) Addition of like fractions.

(9) Subtracting like fractions.

(10) Division of three and four digit numbers by one digit numbers with remainders.

For those students still showing weakness after working with L S I booklets as well as non-readers with weaknesses in one through seven and ten (above), the appropriate section of an A S M D (5) text was assigned. For weaknesses in eight and nine, the appropriate sections of Fractions (11) or Honor Fractions I (4) were assigned.

Level C includes the following:

(1) Addition of three and four digit whole numbers with extensive regrouping and some zeros in the addends.

(2) Subtraction of four digit numbers with and without regrouping.

(3) Multiplication of two and three digit numbers with zeros in the multiplicand or multiplier.

(4) Division by two digit divisor without zeros in the quotient.

(5) Addition of dollars and cents.
(6) Multiplication with extensive use of zeros in the multiplier and multiplicand.

(7) Addition of mixed numbers with like denominators.

(8) Subtraction of mixed numbers with like denominators.

(9) Division by one digit number with remainder expressed as a fraction.

(10) Addition of fractions and mixed numbers with unlike denominators.

(11) Subtraction of fractions and mixed numbers with unlike denominators.

(12) Multiplication of dollars and cents by whole numbers.

(13) Division of dollars and cents by whole numbers.

(14) Addition of like decimals.

(15) Subtraction of like decimals.

For students with continued difficulty with one through four, six, and nine (above) and for non-readers displaying difficulty in these areas, the appropriate section of an A S M D book was assigned. For those displaying difficulty with five, and twelve through fifteen, assignments were selected from Decimals and Percentage I (6) or, for twelve and thirteen, from Decimals and Per Cents (16). For those students displaying difficulty with seven, eight, ten and eleven, sections from Fractions or Honor Fractions II (4) were assigned.
Level D includes the following:

1. Addition of three or more whole numbers.
2. Subtraction of large whole numbers with extensive regrouping and zeros in the minuend.
3. Multiplication of three digit numbers with zeros as the middle digit and use of large numbers.
4. Division by two and three digit divisors.
5. Addition of mixed numbers with unlike denominators and extensive regrouping.
6. Subtraction of fractions with unlike denominators requiring regrouping.
7. Multiplication of common fractions and mixed numbers.
8. Division of common fractions and mixed numbers.
9. Addition of large like decimals and mixed like decimals.
10. Subtraction of large like decimals and mixed like decimals.
11. Multiplication of decimals.
12. Division of decimals.
13. Decimal and fractional equivalent of per cents.

For those students having difficulty with one through four, assignments were taken from A 3 M D. Assignments were selected from Fractions for those having difficulty with five through eight. Those having difficulty with nine and
ten received assignments from **Decimals and Percentage I**.

Assignments from either **Decimals and Percentage I** or **Decimals and Per Cents** were assigned to those having difficulty with eleven and twelve. Difficulties with thirteen and fourteen were met with either **Decimals and Per Cents** or **Decimals and Percentage II (6)**.

Level EF includes the following:

1. Addition of dollars, cents, and dollars and cents with three addends.
2. Subtraction of large numbers with extensive complex regrouping.
3. Multiplication of large numbers.
4. Division of large numbers.
5. Addition of fractions and mixed numbers with three addends.
6. Subtraction of unlike mixed numbers.
7. Multiplication of fractions and mixed numbers with more than one factor.
8. Division by mixed numbers and fractions.
10. Subtraction of unlike decimals and subtraction of decimals and common fractions.
11. Multiplication of decimals.
12. Division of decimals.
For students having difficulty with one and nine through twelve, assignments were made from *Decimals and Percentage L*. If difficulties arose with two through four, assignments were made from the *A S M D series*. Assignments were made from *Fractions* for difficulties with five through eight. Finally, those having difficulties with thirteen, received assignments from *Decimals and Per Cent* or *Decimals and Percentage*.

**Treatment of Data**

The analysis of data involved several steps. The first step required subtracting the pretest scores for each subject from his posttest scores. This produced three gain scores, one for computation skills, one for concept skills, and one for application skills.

The linear effect of age, sex, two scales of the *S R A Primary Mental Abilities Tests* (10), three scales of the *S R A Achievement Tests* (9), and the three scores on the pretest were removed by computing regression equations using these variables as independent variables and the gain scores in each area as dependent variable. Residual gains for each subject in each area were then computed.

The control and experimental groups were then compared on residual gains on all three variables simultaneously by use of Hoetellings T-square. Mean differences were then compared by simultaneous confidence intervals to determine the significance of difference on each variable. The .05 level of significance was required to reject the null hypothesis.
To determine the significance of gain for each group, a Fisher's t test with repeated measures was computed for each group on the three areas of the pretest and posttest. The .01 level of significance was required to reject the null hypothesis to offset the repeated use of t.
CHAPTER BIBLIOGRAPHY


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3. Comprehensive Test of Basic Skills, Level 2, Form R, California Test Bureau, Monterey, California, 1969.


CHAPTER IV

RESULTS

The purpose of this study was to determine the effect of a highly individualized prescriptive program designed to improve computation skills on seventh grade pupils who were achieving at least one year below grade level in arithmetic computation, concepts and reasoning as measured by the SRA Achievement Tests (2). The subjects who were in this experimental program were also compared with a matched control group who continued in the regular arithmetic program of the school in which the experiment was conducted.

This chapter presents the results of each statistical technique employed as it relates to the hypotheses. All computation was done by the North Texas State University Computer Center.

Subject Losses

Two pairs were eliminated from the study because adequate test results were not available on one of the subjects in each pair. The subjects lost did not deviate appreciably from the remainder of the subjects on the test scores available.

It was assumed that the inclusion of these subjects would not affect the results of the study appreciably.
Residualized Gains

The linear effect of sex, age, the two scales of the SRA Primary Mental Abilities Test (3)—number facilities and composite score, the three scales of the SRA Achievement Tests (2) in arithmetic—concepts, reasoning, and computation, and the three areas of the pre-test, Arithmetic Skills Area of the Comprehensive Test of Basic Skills (1)—computation, concepts, and applications—were removed from the gain scores in each of the three areas—computation, concepts, and applications.

Equation A, below, is the regression equation derived for computing the residualized gain score in arithmetic computation.

EQUATION A

REGRESSION EQUATION FOR COMPUTING RESIDUAL GAINS IN COMPUTATION

\[
\begin{align*}
r_1 &= x_1 (1.29) + x_2 (0.030) + x_3 (0.017) + x_4 (0.175) + x_5 (0.526) + x_6 (0.354) + x_7 (0.005) + x_8 (-0.244) + x_9 (-0.119) + x_{10} (0.345) + R (-31.148) \\
&= \text{Sex} + \text{Age} + \text{Number Facility} + \text{Composite I. Q. Score} + \text{SRA Reasoning} + \text{SRA Concepts} + \text{SRA Computation} + \text{Pre-Computation} + \text{Pre-Concepts} + \text{Pre-Applications} + \text{Constant} \\
&= \text{Constant Correlation}
\end{align*}
\]
The values of \( x_1, x_2, x_3, \ldots, x_{10} \) are the differences between the scores or values of each subject on each independent variable (sex, age, number facility, etc.) and the mean of all subjects on that variable.

Residualization eliminated approximately 43 per cent of the variability which would otherwise have been contained in the error term. Decreasing the error term by reducing the variability attributable to known independent variables makes any test for significance more sensitive to any systematic differences in the dependent variable that are related to the primary independent variable. In this case removing the effect of the independent variables which were unrelated to the treatment variable reduced the total variance without systematically effecting the variability attributable to the treatment.

The effects of residualization on means and standard deviations are presented in Table I.

Table I

<table>
<thead>
<tr>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.61</td>
<td>4.95</td>
<td>2.87</td>
<td>3.33</td>
<td>7.48</td>
</tr>
<tr>
<td>2.50</td>
<td>3.70</td>
<td>2.97</td>
<td>3.84</td>
<td>5.47</td>
</tr>
</tbody>
</table>
The mean gain of the experimental group was reduced by residualization. This reduced the mean difference between the experimental and control group even though residualization decreased the mean gain of the control group slightly. It was expected that residualization would decrease the difference between the two means, but, more importantly, it decreased the variance and, therefore, the standard deviation of each group.

The regression equation below, Equation B, is the regression equation derived for computing the residualized gain scores in arithmetic concepts.

**EQUATION B**

**REGRESSION EQUATION FOR COMPUTING RESIDUAL GAINS IN CONCEPTS**

\[
\begin{align*}
x_2 & = x_1 (0.89262) \quad \text{Sex} \\
& + x_2 (0.03909) \quad \text{Age} \\
& + x_3 (0.05062) \quad \text{Number Facility} \\
& + x_4 (0.08508) \quad \text{Composite I.Q. Score} \\
& + x_5 (-0.11882) \quad \text{SRA Reasoning} \\
& + x_6 (-0.05572) \quad \text{SRA Concepts} \\
& + x_7 (0.13173) \quad \text{SRA Computation} \\
& + x_8 (0.07803) \quad \text{Pre-Computation} \\
& + x_9 (-0.25945) \quad \text{Pre-Concepts} \\
& + x_{10} (-0.30435) \quad \text{Pre-Applications} \\
& + (12.30474) \quad \text{Constant} \\
R & = 0.52 \quad \text{Correlation}
\end{align*}
\]
Again the values of $x_1, x_2, x_3, \ldots x_{10}$ are the differences in the scores or values of each subject on each independent variable (sex, age, number facility, etc.) and the mean of all subjects on that variable.

In this case the variability removed was considerably less than in the first case. The variance removed was only about twenty-seven per cent of the total variance. The relationship between the independent variable on which the regression equation was based and the dependent or criterion variable was somewhat less. However, the correlation ($R = .52$) was significant beyond the .05 level of significance.

The effects of residualization on means and standard deviations are presented in Table II.

Table II
THE EFFECT OF RESIDUALIZATION ON CONCEPT GAINS

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Gains Scores</td>
<td>1.13</td>
<td>2.93</td>
<td>-.35</td>
<td>4.23</td>
<td>1.48</td>
</tr>
<tr>
<td>Residualized Gains Scores</td>
<td>.64</td>
<td>2.67</td>
<td>-.83</td>
<td>3.49</td>
<td>1.67</td>
</tr>
</tbody>
</table>

Residualization increased the difference between the mean gain scores of the control and experimental groups as well
as decreasing the standard deviation of each. However, since the correlation was somewhat lower, the decrease in standard deviations were considerably less than was the case with those of the computation gains.

Equation C, below, was used in computing the residualized gain scores in arithmetic applications.

**EQUATION C**

**REgression Equation For Computing Residual Gains In Applications**

\[
\begin{align*}
  r_3 &= x_1 \times (2.37325) + x_2 \times (0.05595) + x_3 \times (0.05405) + x_4 \times (0.09070) + x_5 \times (0.26342) + x_6 \times (0.26534) + x_7 \times (0.01457) + x_8 \times (0.19665) + x_9 \times (-0.03404) + x_{10} \times (-0.97708) + (-26.11228) \\
  R &= 0.71
\end{align*}
\]

Once more, the \(x_1, x_2, x_3, \ldots, x_{10}\) are the deviations of each subject on each of the independent variables (sex, age, number facility, etc.) from the mean of all subjects on each of these variables.
The degree of relationship between the set of independent variables and the criterion variable was unusually high ($R = .71$). Approximately 50 percent of all of the variability observed is attributable to these variables.

Table III below gives the effect of residualization on the means and standard deviations of the experimental and control groups.

TABLE III
THE EFFECT OF RESIDUALIZATION ON APPLICATION GAINS

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Gains Scores</td>
<td>- .61</td>
<td>3.74</td>
<td>- 1.04</td>
<td>3.78</td>
<td>.43</td>
</tr>
<tr>
<td>Residualized</td>
<td>.07</td>
<td>1.94</td>
<td>-.08</td>
<td>1.88</td>
<td>.15</td>
</tr>
<tr>
<td>Gains Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The standard deviations are greatly reduced, but the mean difference is also. Apparently neither the instruction in the experimental program nor the regular classroom instruction had much effect on the application skills of the subjects.

Simultaneous Comparison Between Groups

The residualized gains of the experimental and control groups were compared on all three variables—computation, concepts, and applications—simultaneously by use of Hotelling's T-square. Table IV presents the results of the computation.
TABLE IV

SIMULTANEOUS COMPARISON OF EXPERIMENTAL AND CONTROL RESIDUALIZED GAINS ON THREE VARIABLES BY HOTELLING'S T-SQUARE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Mean</th>
<th>SD</th>
<th>Control Mean</th>
<th>SD</th>
<th>Mean Diff</th>
<th>TSQR</th>
<th>ndf&lt;sub&gt;1&lt;/sub&gt;</th>
<th>ndf&lt;sub&gt;2&lt;/sub&gt;</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comp.</td>
<td>2.50</td>
<td>3.70</td>
<td>-2.97</td>
<td>3.80</td>
<td>5.97</td>
<td>52.48</td>
<td>3</td>
<td>42</td>
<td>8.11</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Conc.</td>
<td>2.74</td>
<td>2.67</td>
<td>-3.34</td>
<td>3.49</td>
<td>1.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appl.</td>
<td>7.07</td>
<td>1.94</td>
<td>-0.08</td>
<td>1.88</td>
<td>1.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The high level of significance (P < .001) suggests a strong tendency toward a systematic difference between the control and experimental groups. An examination of the means shows no interaction; the means of the experimental group are consistently higher than those of the control group. This would indicate a significant superiority for the experimental group.

Hypothesis I

The first research hypothesis stated that the mean gain in arithmetic computation of the subjects in the experimental group would exceed that of the subjects in the control group. The null hypothesis, which stated that there was no significant difference between the experimental and control groups in computation gains, was tested.

Since the Hotelling's T-square showed a difference between the experimental and control groups beyond the required
level of significance ($P \leq 0.05$), the difference between the experimental and control groups on computation gains was compared by simultaneous confidence intervals. This was done to isolate the source of the difference detected by the Hotelling's $T^2$-square. Table V presents the results of this comparison.

**TABLE V**

**COMPARISON OF RESIDUALIZED GAINS IN COMPUTATION**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD*</th>
<th>Difference</th>
<th>Required Dif.</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>2.50</td>
<td>1.36$^*$</td>
<td>5.47</td>
<td>5.06$^{**}$</td>
<td>$P = 0.001$</td>
</tr>
<tr>
<td>Control</td>
<td>-2.97</td>
<td>2.81$^*$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^*$Standard deviation computed from variance in Hotelling's $T^2$-square for use in simultaneous confidence intervals.

$^{**}$Required for .001 level of confidence.

The highly significant difference ($P \leq 0.001$) was more than adequate for rejecting the null hypothesis. The direction of the difference—favoring the experimental group—lended strong support to hypothesis one.

**Hypothesis II**

The second research hypothesis was stated in the null. It stated that there would be no significant difference between the experimental and control groups in arithmetic concepts.

Since the simultaneous test for significance between the experimental and control groups on the three variables—
computation, concepts, and applications---detected a highly significant ($P<.001$) difference which was beyond the level ($P<.05$) required for rejecting the null hypothesis, simultaneous confidence intervals were used to test the difference between the two groups in concept gains. Table VI presents the results of the comparison of these groups.

### Table VI

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD*</th>
<th>Difference</th>
<th>Required Diff</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>.81</td>
<td>1.52</td>
<td>1.67</td>
<td>2.78**</td>
<td>N.S.***</td>
</tr>
<tr>
<td>Control</td>
<td>-.03</td>
<td>1.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*: Standard deviation computed from variance in Hotelling's $T$-square for use in simultaneous confidence intervals.

**: Difference required for .05 level of significance.

***: Not significant.

Since the difference did not reach the required level of significance ($P<.05$), Hypothesis 2 cannot be rejected.

Although the difference between the experimental and control groups did not reach the required level of significance, the direction of the difference favored the experimental group. This fact will be discussed in Chapter V.

**Hypothesis III**

The third research hypothesis, like the second, was stated in the null. It predicted no significant difference between the application-gain scores of the experimental group and those of the control group.
Since the simultaneous comparison of the control and experimental groups on the three gain scores—computation, concepts, and application—indicated a significant difference, the gain scores on arithmetic applications were compared by simultaneous confidence intervals. Table VII presents the results of this comparison.

**TABLE VII**

COMPARISON OF RESIDUALIZED GAINS IN APPLICATION

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD*</th>
<th>Difference</th>
<th>Required Diff.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>.07</td>
<td>1.23*</td>
<td>.15</td>
<td>2.27**</td>
<td>N.S.***</td>
</tr>
<tr>
<td>Control</td>
<td>.08</td>
<td>2.72*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Standard deviation computed from variance in Hotelling's T-square for use in simultaneous confidence intervals.

** Required for .05 level of significance.

***Not significant.

Once again the mean difference did not reach the required level of significance to reject the null hypothesis. Therefore, Hypothesis III must be retained. For future reference it should be noted, however, that the difference between means, although slight, favored the experimental group.

**Hypothesis IV**

The fourth research hypothesis predicted that the post-test scores of the experimental group would exceed the pre-test scores on arithmetic computation. The null hypothesis that there was no difference between the two sets of scores
was tested by the Fisher's $t$ technique with repeated measures. Table VIII presents the results of this test.

TABLE VIII

PRETEST-POSTTEST COMPARISON FOR
THE EXPERIMENTAL GROUP
ON COMPUTATION

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff.</th>
<th>S.D.</th>
<th>$t$</th>
<th>ndf</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Diff.</td>
<td>S.D.</td>
<td>$t$</td>
</tr>
<tr>
<td>34.70</td>
<td>6.85</td>
<td>39.13</td>
<td>7.9</td>
<td>-4.43</td>
<td>5.11</td>
<td>4.07</td>
</tr>
</tbody>
</table>

As is indicated by Table VIII, the pretest and posttest were significantly different well beyond the .01 level required for rejecting the null hypothesis. An examination of the pretest and posttest means reveals that the direction of the difference favors the posttests. Therefore, Hypothesis IV is supported. The experimental subjects did apparently make a significant gain in arithmetic computation.

Hypothesis V

The fifth research hypothesis predicted no significant difference between the pretests and the posttests of the control group on arithmetic computation. Since the research hypothesis was stated in the null it was tested directly by the Fisher's $t$ with repeated measures. Table IX presents the results of this test for significance.
TABLE IX

PRETEST-POSTTEST COMPARISON FOR
THE CONTROL GROUP ON
COMPUTATION

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff.</th>
<th>S.D.</th>
<th>t</th>
<th>ndf</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34.87</td>
<td>7.07</td>
<td>31.91</td>
<td>9.07</td>
<td>2.96</td>
<td>5.28</td>
<td>2.63</td>
</tr>
</tbody>
</table>

*Not significant since the .01 level was required for rejection of the null hypothesis.

Although the difference approached significance (P<.02), the required level of significance (P<.01) was not attained. Therefore, the null hypothesis cannot be rejected. However, since the level of significance was so high, an examination of the means to determine the direction of the difference was deemed necessary. That examination revealed that the direction of the difference favored the pretest. That would indicate a near significant regression in arithmetic computation for the control group. Technically, however, Hypothesis V must be retained.

Hypothesis VI

The sixth research hypothesis predicted no significant difference would be found between the pretest and posttest scores of the experimental group on arithmetic concepts. Since it was stated in the null, this hypothesis was tested directly. The Fisher's t technique for repeated measures was used to test this hypothesis. Table X, following, presents the results of that test.
TABLE X

PRETEST-POSTTEST COMPARISON FOR
THE EXPERIMENTAL GROUP
ON CONCEPTS

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff.</th>
<th>S.D.</th>
<th>t</th>
<th>ndf</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Diff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.39</td>
<td>5.14</td>
<td>19.52</td>
<td>5.10</td>
<td>-1.13</td>
<td>3.10</td>
<td>1.71</td>
</tr>
</tbody>
</table>

*Not significant.

Again the level of significance (P<.01) required for rejection of the null hypothesis was not attained. Therefore, Hypothesis VI, a null hypothesis, must be retained. However, the difference, which did approach the .10 level of significance, was large enough to require an examination of the means to determine the direction of that difference. That examination revealed that the difference favored the posttest. It could then be concluded that, although the experimental group did not attain a significant gain, it is much less probable that the program could have had an adverse effect on their arithmetic concept skills.

Hypothesis VII

The seventh research hypothesis was stated in the null. It predicted that no significant difference would be found between the pretest and the posttest of the control subjects on arithmetic concepts. The Fisher's t technique with repeated measures was used to test the hypothesis. Table XI presents the results of this test.
TABLE XI
PRETEST-POSTTEST COMPARISON FOR THE CONTROL GROUP ON CONCEPTS

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Posttest</th>
<th>Mean</th>
<th>S.D.</th>
<th>t</th>
<th>ndf</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Diff.</td>
<td>Diff.</td>
<td></td>
</tr>
<tr>
<td>18.43</td>
<td>5.12</td>
<td>17.78</td>
<td>5.49</td>
<td>.65</td>
<td>1.22</td>
<td>.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.73</td>
<td>22</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Not significant.

It is apparent from Table XI that the slight difference in means of the pretest and posttest is not significant at the required level (P<.01) for rejecting the null hypothesis. Therefore, Hypothesis VII must be retained. Furthermore, even though an examination of the means reveals a slight loss from the pretest to the posttest, this difference is so small that no tendency can be determined.

Hypothesis VIII

The eighth research hypothesis predicted that no significant difference would be found between the pretest and posttest scores of the experimental subjects in arithmetic applications. Since the research hypothesis was stated in the null, it was tested directly by the Fisher's $t$ technique with repeated measures. Table XII present the results of this test.
TABLE XII
PRETEST-POSTTEST COMPARISON FOR
THE EXPERIMENTAL GROUP
ON APPLICATIONS

<table>
<thead>
<tr>
<th>Pretest Mean</th>
<th>Pretest SD</th>
<th>Posttest Mean</th>
<th>Posttest SD</th>
<th>Mean Diff.</th>
<th>SD Diff.</th>
<th>t</th>
<th>ndf</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.09</td>
<td>3.39</td>
<td>10.35</td>
<td>3.57</td>
<td>-.74</td>
<td>2.91</td>
<td>1.19</td>
<td>22</td>
<td>NS*</td>
</tr>
</tbody>
</table>

*Not significant.

As predicted, the mean difference as shown in Table XII was not significant at the required level (P<.01) for rejection of the null hypothesis. Thus, Hypothesis VIII would appear to be tenable. As was the case with the difference in concept scores for the control subjects, the difference in the application scores for the experimental subjects—although showing a slight loss—is too small to detect a definite trend.

Hypothesis IX

The ninth research hypothesis predicted that no significant difference would be found between the pretest and posttest scores of the control subjects on arithmetic applications. Since the research hypothesis was stated in the null, it was tested directly by the Fisher's t technique with repeated measures. Table XIII presents the result of this test.
As Table XIII indicates the pretest-posttest difference did not reach the required level (P<.01) for rejection of the null hypothesis. It was, therefore, assumed that Hypothesis IX was tenable. An examination of the means showed that difference indicated a mean loss for the control subjects in arithmetic application. This loss, however, was too small in comparison to the standard deviation of the differences to detect a definite trend.
CHAPTER BIBLIOGRAPHY

1. Comprehensive Test of Basic Skills, Level 2, Form Q, California Test Bureau, Monterey, California, 1968.


CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter contains six parts. The first part is a brief summary of the experiment. Next is a presentation of the findings. The next four parts present conclusions, clinical observations, educational implications, and specific recommendations.

Summary

The purpose of this study was to determine the effect of prescriptive teaching of remedial arithmetic on seventh-grade pupils who were achieving at least one year below grade level in arithmetic computation, concepts and application skills. A second purpose was to compare the effectiveness of prescriptive teaching of arithmetic computation with ordinary classroom instruction on the three variables—computation, concepts, and applications.

Twenty-five pairs of seventh-grade pupils who were matched on computation, concept and application skills and who had scored in the lower quartile on all scales of the arithmetic section of a standardized achievement test were selected for the study. One subject from each pair was randomly assigned to the experimental group and the other to the control group.
The subjects in the control group returned to their regular classroom and received no further special attention until the posttest.

The subjects assigned to the experimental group received a concentrated seven-week course on computation skills utilizing a number of commercial programmed materials. Every effort was made to provide the experiences appropriate for the level of attainment of each subject at all times. The appropriate material was determined by a diagnostic test administered at the beginning of the program. Progress was constantly noted and the subject was allowed to progress from one area of difficulty to another when he displayed competency in the previous area. Each subject received personal attention every day. Records of progress were kept for each subject.

The posttests were administered to both the experimental subject and his match together in groups that did not exceed fourteen subjects. Two subjects were not available for posttesting; therefore, both their scores and the scores of their matches were deleted from the study.

The test scores were analyzed in two ways to test nine research hypotheses. First, the residualized gain scores of the experimental subjects were compared with those of the control subject on the three areas of the pretest and posttest—computation, concepts and applications. The second technique was a comparison between the pretests and posttests for both the experimental and control groups on the three variables.
Below are the nine research hypotheses tested.

1. Mean gain in arithmetic computation of subjects in the experimental program will exceed that of the control subjects.

2. No significant difference will be found between the mean gain of the subjects in the experimental program and that of the control subjects in arithmetic concepts.

3. No significant difference will be found between the mean gain of the subjects in the experimental program and that of the control subjects in arithmetic concepts.

4. The scores of the posttests for the subjects in the experimental program will be significantly higher than the pretest scores on arithmetic computation.

5. No significant differences will be found between pretests and posttests on arithmetic computation for the control subjects.

6. No significant differences will be found between the pretests and posttests on arithmetic concepts for the subjects in the experimental program.

7. No significant differences will be found between the pretests and posttests on arithmetic concepts for the control subjects.

8. No significant differences will be found between the tests and posttests on arithmetic application for the subjects in the experimental program.

9. No significant differences will be found between the pretests and the posttests on arithmetic application for the
Findings

The results of the simultaneous comparison of the gain scores of the experimental and control subjects on computation, concepts and applications indicated a marked superiority for the experimental group over the control group on one or more of these variables. The chance of such large differences occurring by chance was less than one in one-thousand. Most of the difference occurred in the computation skills area of the tests, but the means of the residualized gain scores in concepts and applications also favored the experimental group.

The first research hypothesis, which predicted greater gains for the subjects in the experimental program than for the control subjects in arithmetic computation, was supported. The difference, which favored the experimental program, was found to be significant beyond the .001 level.

Hypothesis 2, which predicted no significant difference between the gain scores of the experimental and control subjects in arithmetic concepts, was retained. Although there was a slight difference in the means of the residualized gain scores favoring the experimental program, this difference did not reach the required level of significance (P<.05) for rejection of the null hypothesis.

The third hypothesis predicted no significant difference between the gain scores of the experimental and control subjects in arithmetic applications. This hypothesis was retained. Although there was a mean difference favoring the experimental program, the required level of significance for rejection of the null hypothesis was not attained.
Hypothesis 4 predicted significantly higher posttest scores than pretest scores for the experimental subjects on computation. This hypothesis was supported when the difference between the means indicated a gain significant beyond the .001 level.

The fifth hypothesis predicted no difference between the pretest and posttest scores of the control subjects on computation. The hypothesis was retained when the required level of significance for rejection ($P < .01$) was not attained. The difference was near significant ($P < .02$), but an examination of the means disclosed that the direction of the difference indicated a near significant loss rather than gain.

No significant difference between the pretest and posttest of the experimental subjects on arithmetic concepts was predicted by the sixth hypothesis. Although the difference indicated a gain, it did not reach the required level of significance ($P < .01$). The hypothesis was, therefore, retained.

Similarly, no significant difference between the pretest and posttest scores of the control subjects on arithmetic concepts was predicted by Hypothesis 7. The hypothesis was retained when the difference, which indicated a very slight loss, failed to reach the required level of significance.

The eighth hypothesis, which predicted no difference between the pretest and posttest scores of the experimental group on arithmetic applications, was retained when the difference, which indicated a slight mean loss, failed to reach the required level of significance.
The ninth and last hypothesis predicted no significant difference between the pretests and posttests of the control subjects. The hypothesis was retained when the difference, which indicated a slightly greater mean loss than the experimental group had shown on this variable, failed to reach the required level of significance.

Conclusions

The effect of a highly individualized prescriptive teaching program in which underachievers in arithmetic received remedial instruction via programmed or self-instructional materials in arithmetic computation was studied. The following conclusions were drawn from the findings.

1. Greater gains in computational skills are made in a prescriptive program such as the one described in this study than in the ordinary classroom situation.

2. Subjects in a program such as the one described in this study at least as well as subjects in the ordinary classroom situation in arithmetic concept and application skills.

3. Computational skills can be improved by a prescriptive program such as the one described in this study.

4. No loss appears in the related areas of arithmetic concepts and applications when a concentrated attack on computation weaknesses is made.

5. No gain in arithmetic computation, concepts, or application is made by underachievers in arithmetic during
the last seven weeks of school in the ordinary classroom situation.

6. Programmed materials, when selectively utilized for specific goals, can be effectively combined in a flexible sequence of learning activities.

Clinical Observations

Most subjects progressed very smoothly through the tasks prescribed for them. Unfortunately, however, this was not uniformly true. Two distinct types of problems presented themselves. The first type of problem involved students who misused the materials. They frequently were noticed looking to the reinforcement frames for the answers rather than trying to solve the problems themselves. This problem was similar to the student copying the answers from the back of a standard textbook. Although effort was made to eliminate this type of behavior, it was only partially successful.

The second type of problem encountered was much worse in many ways. Some students were persistently disruptive. This created a serious problem in one of two ways. Either they required excessive attention which took time from constructive teaching activities, or they distracted the attention of others. The small group setting probably served as a catalyst for the disruptive behavior of these students. This problem was more pronounced in classes which contained all boys or all girls. A more autocratic teacher-student relationship might have been more effective in dealing with these problems.
The problems mentioned above are but further recommendations for prescriptive teaching with the addition of more alternatives. Not all relevant variables were considered in this study.

A subject who had difficulty learning with a particular type of programmed material initially usually had difficulty with that type of program throughout the study. Although this was not universally true, the tendency was marked. It should be pointed out, however, few subjects showed difficulty with any of the materials since they were selected to meet the individual needs of each subject.

Fatigue was a very significant factor limiting the progress of the subjects in the experimental program. Fatigue worked in two ways. First, a full period was too long a time for most subjects to concentrate on the same type of activity. The second way in which fatigue became a factor was when a subject spent too much time on the same program or dealing with the same problem area. Short programs with specific short term objectives were found to be more effective than longer programs with delayed gratification or complex objectives.

It should be pointed out that the observations above are just observations. They are not the result of scientific analysis. It would seem feasible to make an investigation of some of these variables.
Implications

Strengthening students with serious weaknesses in arithmetic must remain a primary concern of all teachers of mathematics as well as other interested groups. It is hoped that the following implications of this study will be of use to anyone seeking guidelines for selecting or developing a program of remedial arithmetic.

1. Serious consideration should be given to the idea of prescriptive remediation of specific skills.

2. The use of selected programmed materials should be given consideration as a means of individualizing instruction.

3. Fear of removing pupils from the ordinary classroom situation for remediation of specific learning problems were within the scope of this study, unfounded.

4. Although the results of this study show a great deal of promise for the prescriptive teaching of computation skills, a direct attack on computation weaknesses should not be seen as the only means by which these weaknesses can be remediated.

Recommendations

The highly significant findings of this study would present a number of possible recommendations. It would be of value to conduct the following studies:

1. A study of this type in a larger school district with more subjects.

2. A study of this type in which the same teachers taught both the experimental and control subjects.
3. A study to determine the effect of class size on the effectiveness of prescriptive teaching.

4. A study to determine the effectiveness of prescriptive teaching in other subject areas.

5. A study to evaluate a program such as this one on a part time basis.

6. A study to evaluate a program such as this as a continuous program with students entering and leaving as their individual needs dictate.

7. A study like this to determine retention.

8. A study of this type for more able students.

The recommendations above are but a few of the many possible extension of this study. It is hoped that they be given serious consideration since the only means by which the needs of all pupils can be met is by individualization of instruction. And, if individualized instruction is to be effective, some basis for the selection of learning activities must be used. It is believed that the judgement of professionally trained teachers who have been made aware of the individual needs and abilities of the pupils in their classes would be superior to either the hit-or-miss method of group instruction or the principle of self-selection in which pupils blindly try to select learning activities for themselves.

One final recommendation can be made on the basis of this study. Since it has been shown that a program of prescriptive teaching such as the one described is a very
effective means by which to overcome specific skill weaknesses, it is recommended that his type of program be initiated in at least some of the schools receiving Federal money for the improvement of educational opportunities for the culturally deprived. This recommendation should apply not only to those schools receiving financial assistance, but also to any school with adequate commitment to the educationally disadvantaged.
APPENDIX
PROGRESS SHEET

Pupil: Sheryl Brabham
Reading Level: 7.2

Pretest Scores:
- Computation: 34
- Concepts: 20
- Applications: 13

<table>
<thead>
<tr>
<th>Date</th>
<th>Material</th>
<th>Problem Area</th>
</tr>
</thead>
<tbody>
<tr>
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<td>LS I Locator - Addition</td>
<td>Diagnostic</td>
</tr>
<tr>
<td>4/9</td>
<td>LS I Locator - Subtraction</td>
<td>Diagnostic</td>
</tr>
<tr>
<td>4/9-11</td>
<td>LS I Locator - Multiplication</td>
<td>Diagnostic</td>
</tr>
<tr>
<td>4/11-14</td>
<td>LS I Locator - Division</td>
<td>Diagnostic</td>
</tr>
<tr>
<td>4/14-16</td>
<td>LS I Addition - Level C</td>
<td>Addition of Fractions</td>
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Posttest Scores:
- Computation 43
- Concepts 23
- Applications 18
PROGRESS SHEET

Pupil: Richard Crawford

Reading Level: 5.1

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* With auditory reading assistance
PROGRESS SHEET

Pupil: Brenda Hill

Reading Level: 7.1

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<td>L S I Sub. - Level C</td>
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PROGRESS SHEET

Pupil: Cheryl Trapp
Reading Level: 6.8

Pretest Scores:
- Computation: 38
- Concepts: 19
- Applications: 9

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Posttest Scores:
- Computation: 39
- Concepts: 23
- Applications: 11
**PROGRESS SHEET**

**Pupil:** Jerry Turner  

**Reading Level:** 6.5  

**Pretest Scores:**  
- Computation: 28  
- Concepts: 24  
- Applications: 14  

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**Posttest Scores:**  
- Computation: 39  
- Concepts: 23  
- Applications: 15
PROGRESS SHEET

Pupil: Roy Paxton

Reading level: 6.1

Pretest Scores:
- Computation: 35
- Concepts: 9
- Applications: 10

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Posttest Scores:
- Computation: 42
- Concepts: 14
- Applications: 8
**PROGRESS SHEET**

**Pupil:** Rosalind Jones

**Reading Level:** 6.8

**Pretest Scores:**

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Pupil: George Davis  
Reading Level: 4.1  

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*With auditory reading assistance
# PROGRESS SHEET

**Pupil:** Randy Testorman  
**Reading Level:** 6.6

**Pretest Scores:**  
- Computation: 40  
- Concepts: 24  
- Applications: 18

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**Posttest Scores:**  
- Computation: 48  
- Concepts: 23  
- Applications: 18
### PROGRESS SHEET

**Pupil:** James Miller  
**Reading Level:** 6.1

**Pretest Scores:**  
- **Computation:** 20  
- **Concepts:** 9  
- **Applications:** 4

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**Posttest:**  
- **Computation:** 40  
- **Concepts:** 15  
- **Applications:** 10
BIBLIOGRAPHY

Books

Brueckner, Leo J., Lessons for Self-Instruction, Monterey, California, California Test Bureau, 1965.


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